FPM 84-1
Feb 1984

Herbicide Spray Drift Predictions Using the Forest Service FSCBG Forest Spray Model

A Report by H.E. Cramer Co.
Salt Lake City, Utah

USDA Forest Service
Forest Pest Management
2810 Chiles Road
Davis, CA. 95616

Disclaimer Statements: The use of trade, firm or corporation names is for the information and convenience of the reader. Such use does not constitute an official evaluation, conclusion, recommendation, endorsement or approval of any product or service to the exclusion of others which may be suitable.

All uses of pesticides must be registered by appropriate state and/or federal agencies before they can be recommended.

PREFACE

The work reported herein was performed by the H. E. Cramer Company, Inc., P. O. Box 8049, Salt Lake City, Utah 84108 for the USDA Forest Service. The purpose of the work was to demonstrate the use of the Forest Service Cramer-Barry Grim (FSCBG) Forest Spray Model as a means of predicting the drift/deposition of aerially-applied herbicides downwind from a spray block containing seedlings and brush. The model calculations of herbicide deposition described in this report are based on a hypothetical spray scenario in which a tank mixture of water and 2,4-D is applied by a Hiller 12E helicopter to the spray block. The deposition calculations apply to flat terrain and do not include the canopy-penetration features of the FSCBG model.

HERBICIDE SPRAY DRIFT PREDICTIONS USING THE FOREST SERVICE FSCBG FOREST SPRAY MODEL[1]

by

James E. Rafferty[2]

This report presents example calculations made by the FSCBG forest spray model (Dumbauld, et al, 1980) of the drift/deposition of herbicide downwind from a spray block containing seedlings and brush. In the spray scenarios used as the basis for the example model predictions of herbicide drift, a Hiller 12E helicopter applies a tank mix of 95% water and 5% 2,4-D at a rate of 10 gallons per acre to the spray block area. The spray block area was set equal to 120 acres and the helicopter was assumed to fly along 40 swath lines, each 1000 meters (3281 feet) in length, at heights of 3 and 15.2 meters (10 and 50 feet) above the top of the brush. A swath width of 12.2 meters (40 feet) was also assumed.

In the FSCBG model calculations, the water in the spray mixture was allowed to evaporate while the 2,4-D was assumed to be nonvolatile. The initial drop-size distribution of the liquid spray mixture assumed in the calculations is shown in Table 1. Other source parameter values used in the model calculations are given in Table 2. Model predictions were made for the three meteorological regimes specified in Table 3. The mean wind speeds and turbulence parameters in Table 3 are based on climatological estimates presented by Dumbauld (1982). The meteorological input parameters required by the FSCBG model for the three regimes and for the assumed spray release heights of 3 and 15.2 meters (10 and 50 feet) are shown in Table 4.

---

1 Prepared for USDA Forest Service, Forest Pest Management, Davis, CA under Purchase Order No. 40-91S8-3-1583 dated August 1983; John W. Barry, USDA Forest Service Project Officer.

2 Meteorologist, H. E. Cramer Co., P. O. Box 8049, Salt Lake City, UT 84108.

DISPERSION [illegible] PREDICTIONS [illegible]
[illegible] FOREST SPRAY model[1]

by

James A. Rafferty[2]

This report presents example calculations using the FSCBG forest spray model (Dumbauld, et al., 1980) of the drift deposition [illegible] of herbicide [illegible] from a spray block containing seedlings and brush. In [illegible] the [illegible] used as the basis for the example model predictions [illegible] a Bell [illegible] helicopter applies a tank mix of [illegible] water and [illegible] at a rate of 10 gallons per acre to the spray block area. The spray block area was set equal to 100 acres and the helicopter was assumed to fly 16 swath lines, each 1000 meters (3280 feet) in length, at heights of 3 and 15.2 meters (10 and 50 feet) above the top of the brush. A swath width of 12.2 meters (40 feet) was also assumed.

In the FSCBG model calculations, the water in the spray mixture was allowed to evaporate while the [illegible] was assumed to be nonvolatile. The initial drop-size distribution of the liquid spray material assumed in the calculations is shown in Table 1. Other model input parameter values used in the model calculations are given in Table 2. Model predictions were made for the three meteorological regimes specified in Table 3. The mean wind speeds and turbulence parameters in Table 3 are based on climatological estimates presented by Dumbauld (1982). The meteorological input parameters required by the FSCBG model for the three regimes and for the assumed spray release heights of 3 and 15.2 meters (10 and 50 feet) are shown in Table 3.

[1] Prepared for USDA Forest Service, Forest Pest Management, Davis, CA under Purchase Order No. [illegible] dated August 1983. [illegible], USDA Forest Service Project Officer.

[2] [illegible], H. E. Cramer Co., Inc., P. O. Box 8049, Salt Lake City, UT 84108.

TABLE 1

DROP-SIZE DISTRIBUTION

Drop-Size Category	Mean Drop Diameter (μm)	Fraction of Total Mass in Category
1	3966	.001
2	2900	.009
3	2143	.02
4	1774	.03
5	1537	.04
6	1310	.10
7	1092	.10
8	951	.10
9	800	.20
10	661	.10
11	579	.10
12	501	.10
13	423	.04
14	355	.03
15	298	.02
16	209	.01

Note: The volume median diameter (VMD) of the distribution is 800 μm.

TABLE 2

SOURCE MODEL INPUTS

WINGSPAN (ROTOR LENGTH) (m)	10.8
AIRCRAFT WEIGHT (Kg)	1034
AIRCRAFT SPEED ($m\ s^{-1}$)	22.4
AIRCRAFT/SPRAY RELEASE HEIGHT (m)	3,15.2
SWATH WIDTH (m)	12.2
APPLICATION RATE (gallons/acre)	10
ACTIVE INGREDIENT FRACTION (%)	5

TABLE 3

SPECIFIED METEOROLOGICAL REGIMES

<table>
<tr><th rowspan="2">Regime</th><th rowspan="2">Stability</th><th rowspan="2">Wind Speed at 2 m (mph)</th><th rowspan="2">Air Temperature (°F)</th><th rowspan="2">Relative Humidity (%)</th><th colspan="2">Turbulence Parameters (deg)</th></tr>
<tr><th>σ_A (z=10m, τ=600s)</th><th>σ_E (z=10m)</th></tr>
<tr><td>1</td><td>Stable</td><td>2</td><td>60</td><td>80</td><td>10</td><td>3.5</td></tr>
<tr><td>2</td><td>Unstable</td><td>6</td><td>70</td><td>50</td><td>16</td><td>6</td></tr>
<tr><td>3</td><td>Unstable</td><td>10</td><td>90</td><td>30</td><td>13</td><td>5.3</td></tr>
</table>

TABLE 4

METEOROLOGICAL MODEL INPUTS

<table>
<tr><th>Regime</th><th>Release Height (m)</th><th>Transport Wind Speed (m s^{-1})</th><th>Air Temperature (°C)</th><th>Relative Humidity (%)</th><th>Mean σ_A (τ=2.5s) (deg)</th><th>Mean σ_E (deg)</th></tr>
<tr><td rowspan="2">1</td><td>3.0</td><td>0.9</td><td rowspan="2">15.6</td><td rowspan="2">80</td><td>3.9</td><td>3.5</td></tr>
<tr><td>15.2</td><td>1.2</td><td>3.5</td><td>3.5</td></tr>
<tr><td rowspan="2">2</td><td>3.0</td><td>2.7</td><td rowspan="2">21.1</td><td rowspan="2">50</td><td>6.3</td><td>4.5</td></tr>
<tr><td>15.2</td><td>3.1</td><td>5.7</td><td>5.7</td></tr>
<tr><td rowspan="2">3</td><td>3.0</td><td>4.6</td><td rowspan="2">32.2</td><td rowspan="2">30</td><td>5.0</td><td>4.0</td></tr>
<tr><td>15.2</td><td>5.1</td><td>5.0</td><td>5.0</td></tr>
</table>

The transport wind speeds in Table 4 are averages for the height interval extending from 2 meters above ground level to the spray release height. The values of the turbulence parameters in Table 4 have been adjusted for a source emission time of 2.5 seconds typical of aircraft spray systems and are also mean values between 2 meters and the spray release height.

Plots of herbicide deposition isopleths (lines enclosing calculated deposition values equal to or greater than the isopleth value) for the two release heights and three meteorological regimes are presented in Figures 1 through 6. In each case, the deposition isopleths are labeled in units of gallons per acre of the deposited active ingredient 2,4-D. As shown in Figure 1, the drift of the herbicide beyond the downwind edge of the spray block is restricted to very short distances under meteorological regime 1 because of the low wind speeds, low turbulence values and the high humidity assigned to this case which reduces drop evaporation and thus results in large drop settling velocities. Because the deposition falls off rapidly with distance from the spray block in all of the example calculations, detailed plots of the deposition isopleths for the small area in the upper left-hand corner of Figures 1 through 6 are given in Figures 7 through 12. We have also constructed curves of 2,4-D deposition along the cloud drift centerline downwind from the spray block for the three meteorological regimes. These curves are shown in Figures 13 and 14 for release heights of 15.2 meters (50 feet) and 3 meters (10 feet), respectively. As might be expected from qualitative reasoning, the results of the model calculations show that the maximum distance of herbicide drift occurs for meteorological regime 3 (Figures 3 and 9) and a release height of 15.2 meters (50 feet). Because of the low humidity assumed in this case, the water from the smallest drops of the initial drop-size distribution shown in Table 1 is completely evaporated before the drops reach the ground and thus drops of pure 2,4-D with small gravitational settling velocities are transported relatively large distances before they are deposited. In all

the other example calculations, the predicted deposition of herbicide does not extend beyond a distance of 100 meters from the downwind edge of the spray block.

The results of the FSCBG model calculations presented in this report indicate that, for herbicide spray applications, the herbicide drift downwind from the spray block is minimized by spraying at aircraft altitudes below 50 feet when the mean wind speeds are less than 10 miles per hour.

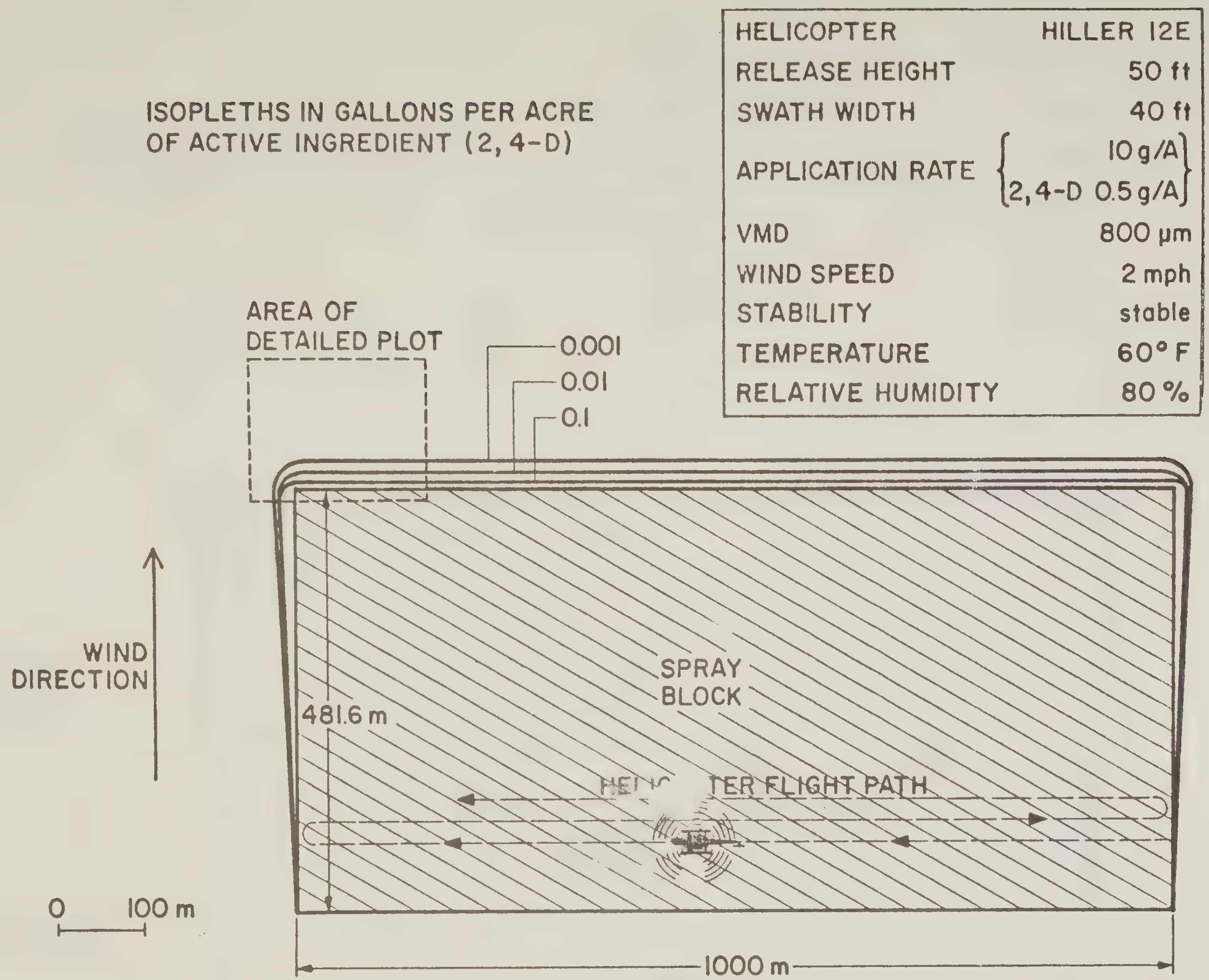

FIGURE 1. Prediction of drift for a release height of 50 ft. and a wind speed of 2 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 7.

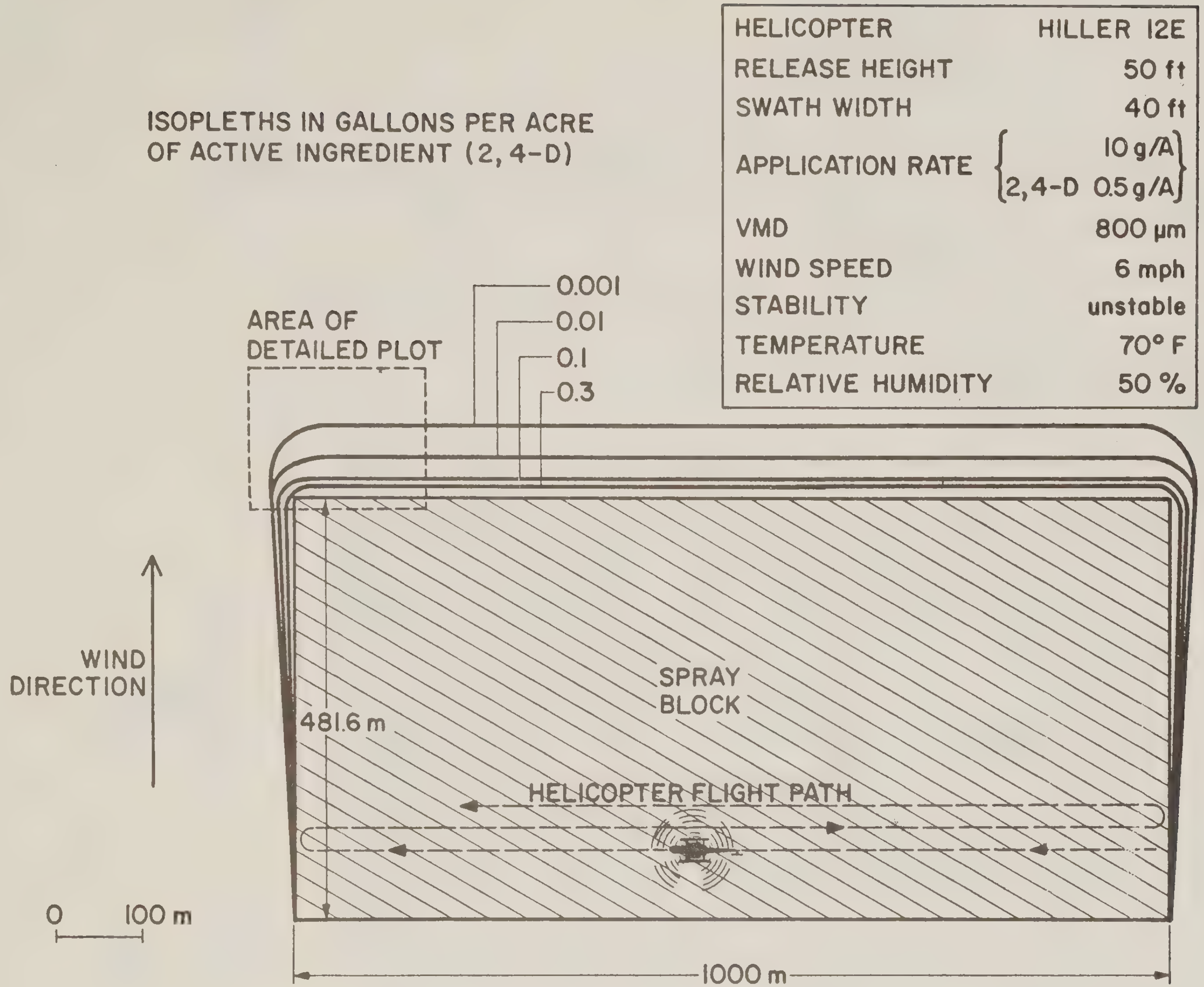

FIGURE 2. Prediction of drift for a release height of 50 ft. and a wind speed of 6 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 8.

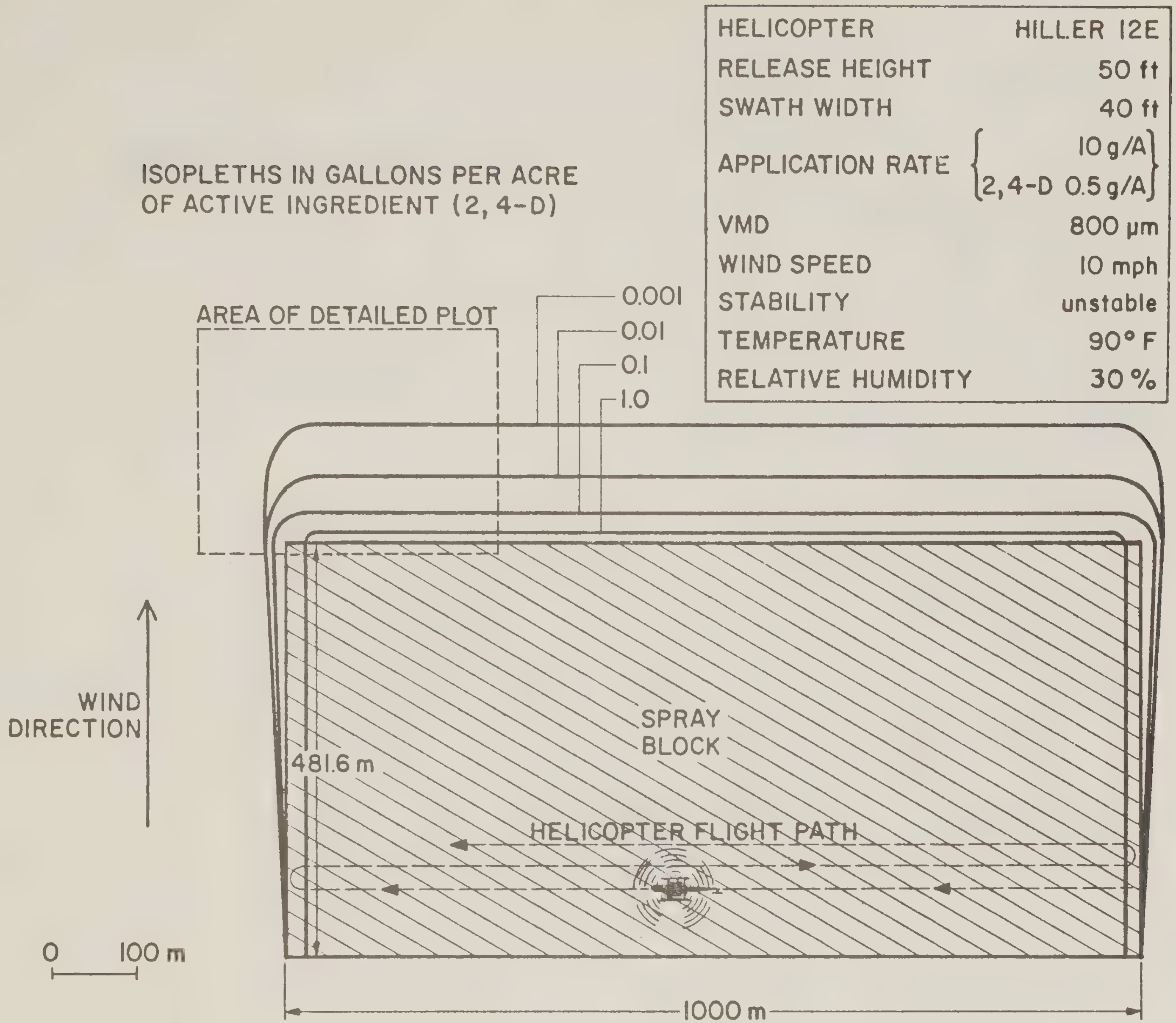

FIGURE 3. Prediction of drift for a release height of 50 ft. and a wind speed of 10 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 9.

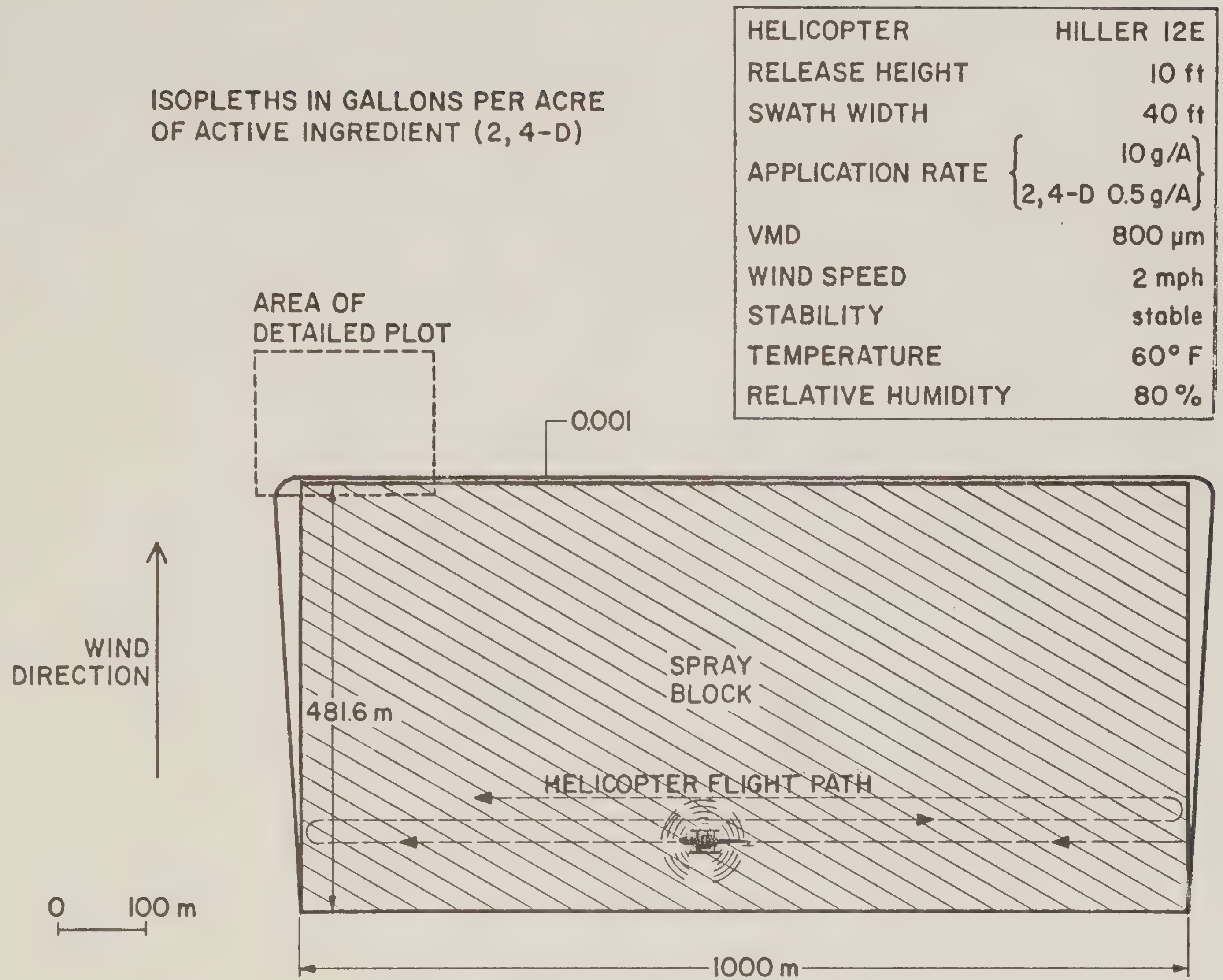

FIGURE 4. Prediction of drift for a release height of 10 ft. and a wind speed of 2 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 10.

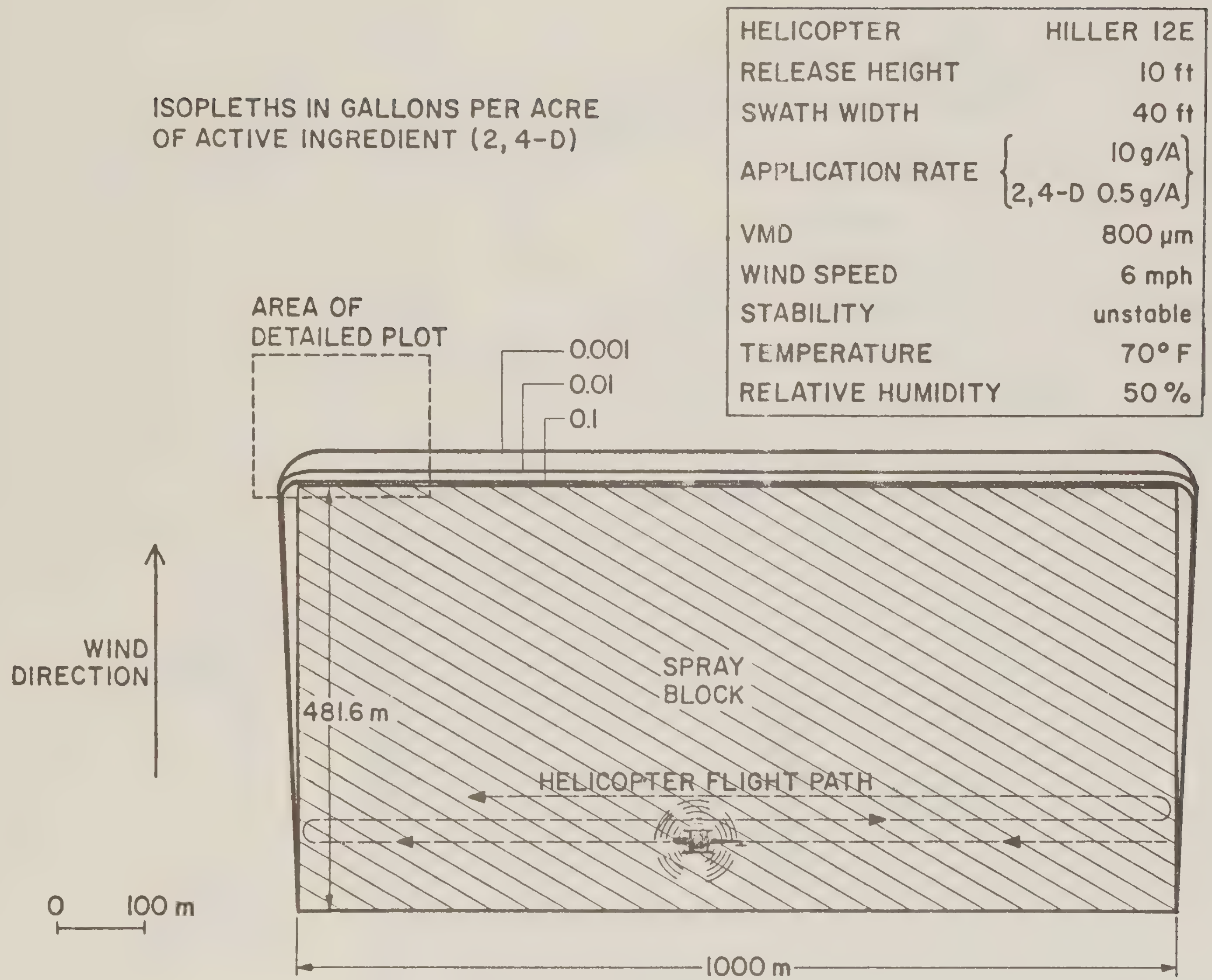

FIGURE 5. Prediction of drift for a release height of 10 ft. and a wind speed of 6 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 11.

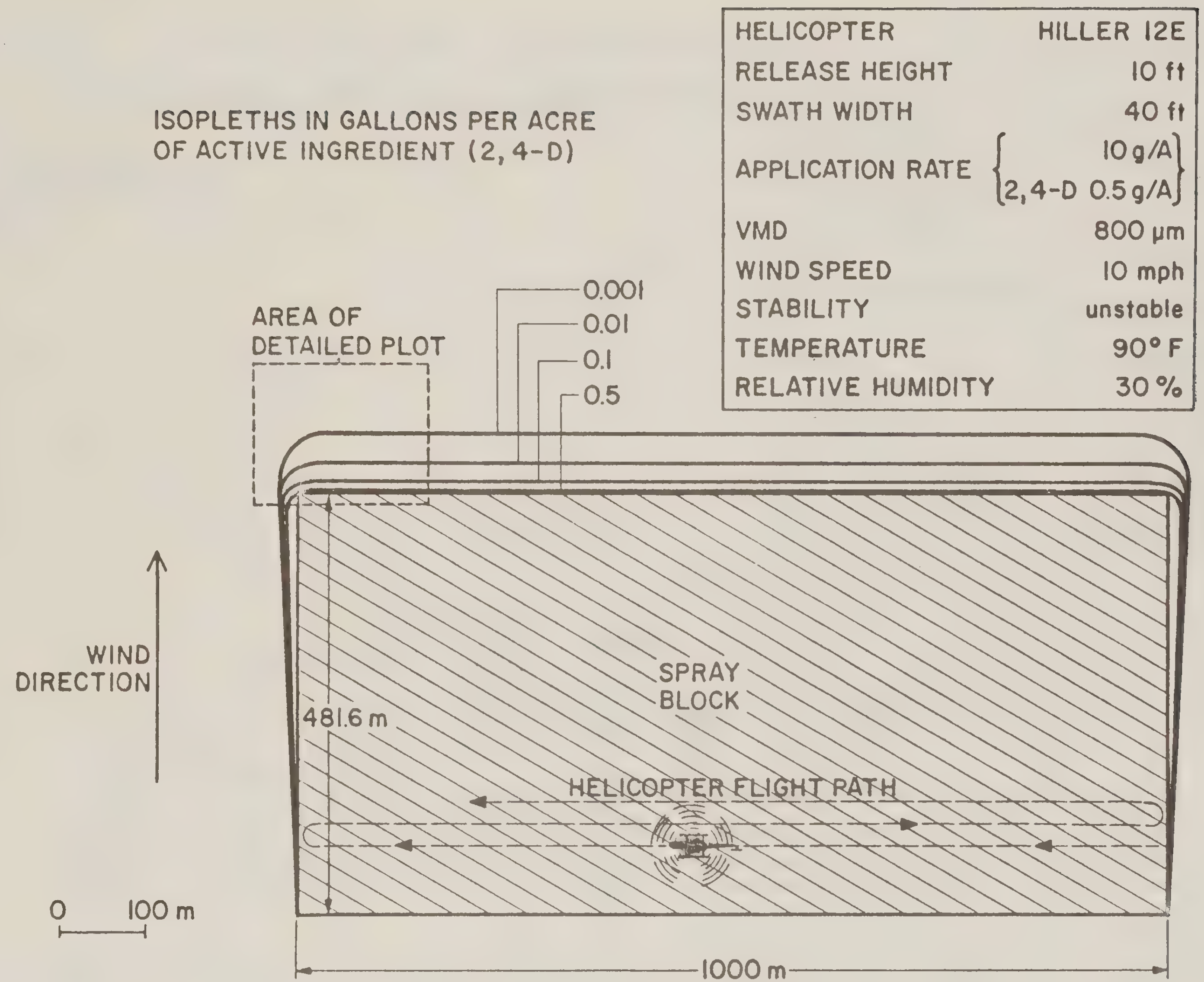

FIGURE 6. Prediction of drift for a release height of 10 ft. and a wind speed of 10 mph. Deposition isopleths for the dashed area of detailed plot are shown in Figure 12.

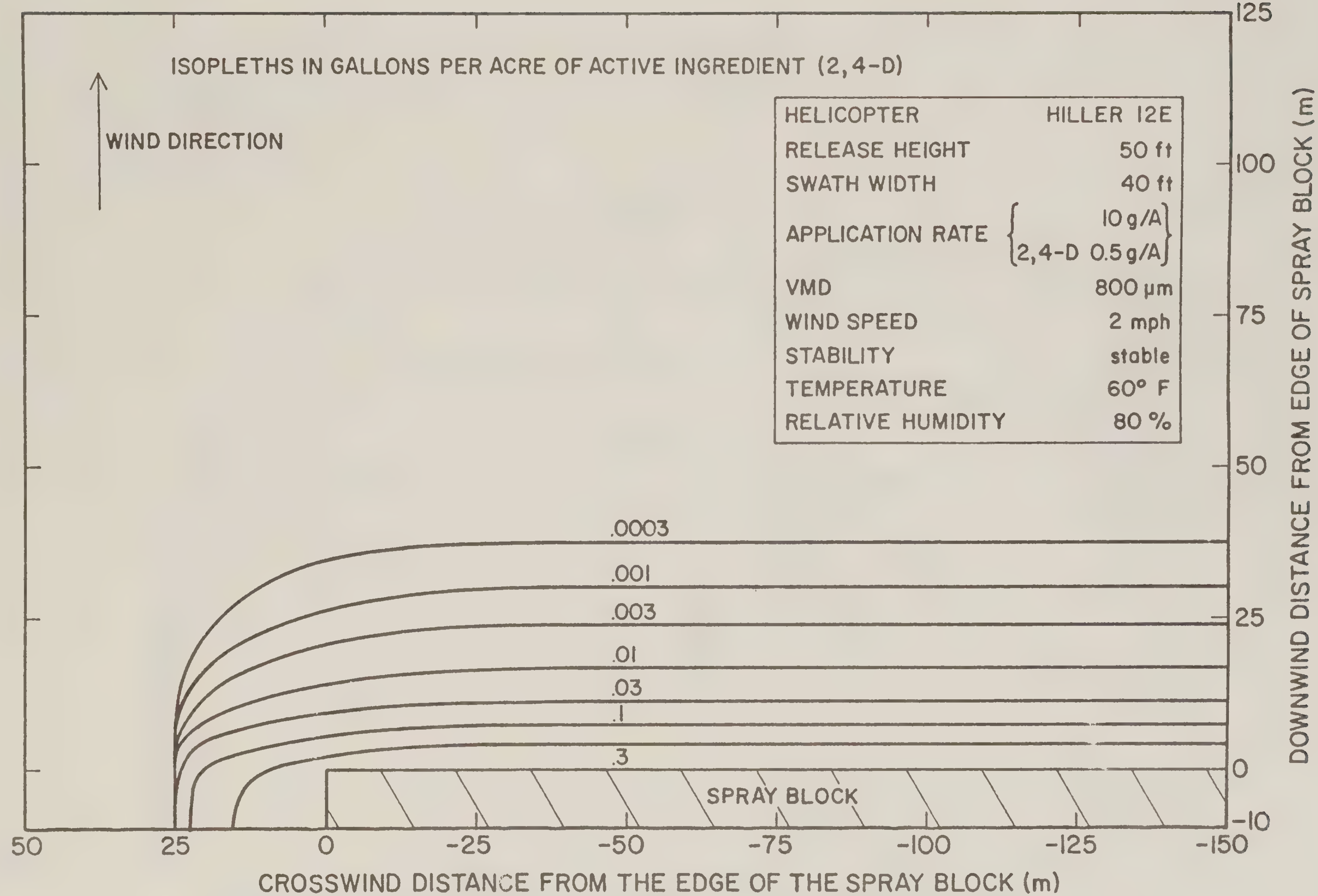

FIGURE 7. Detailed prediction of drift for a release height of 50 ft. and a wind speed of 2 mph.

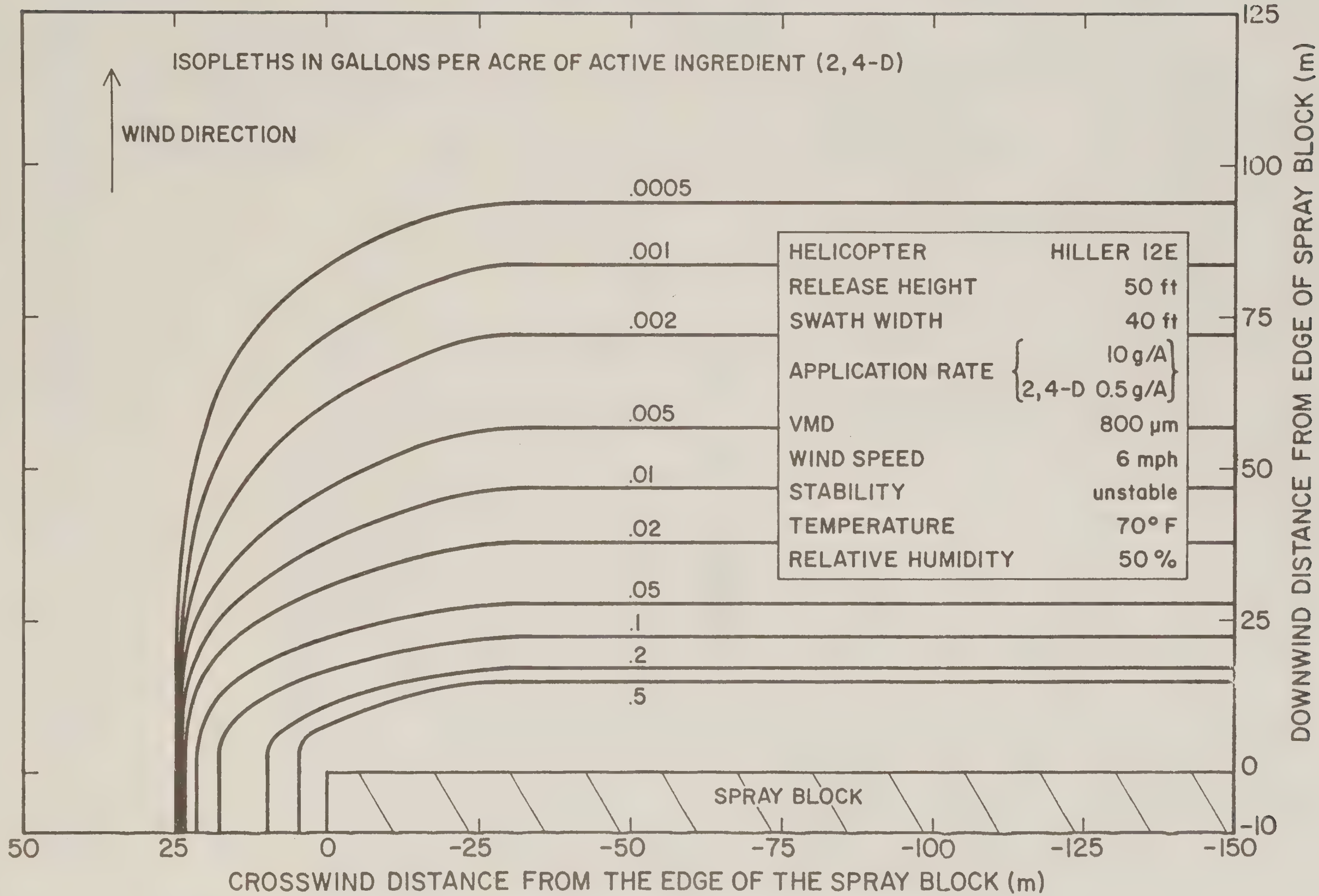

FIGURE 8. Detailed prediction of drift for a release height of 50 ft. and a wind speed of 6 mph.

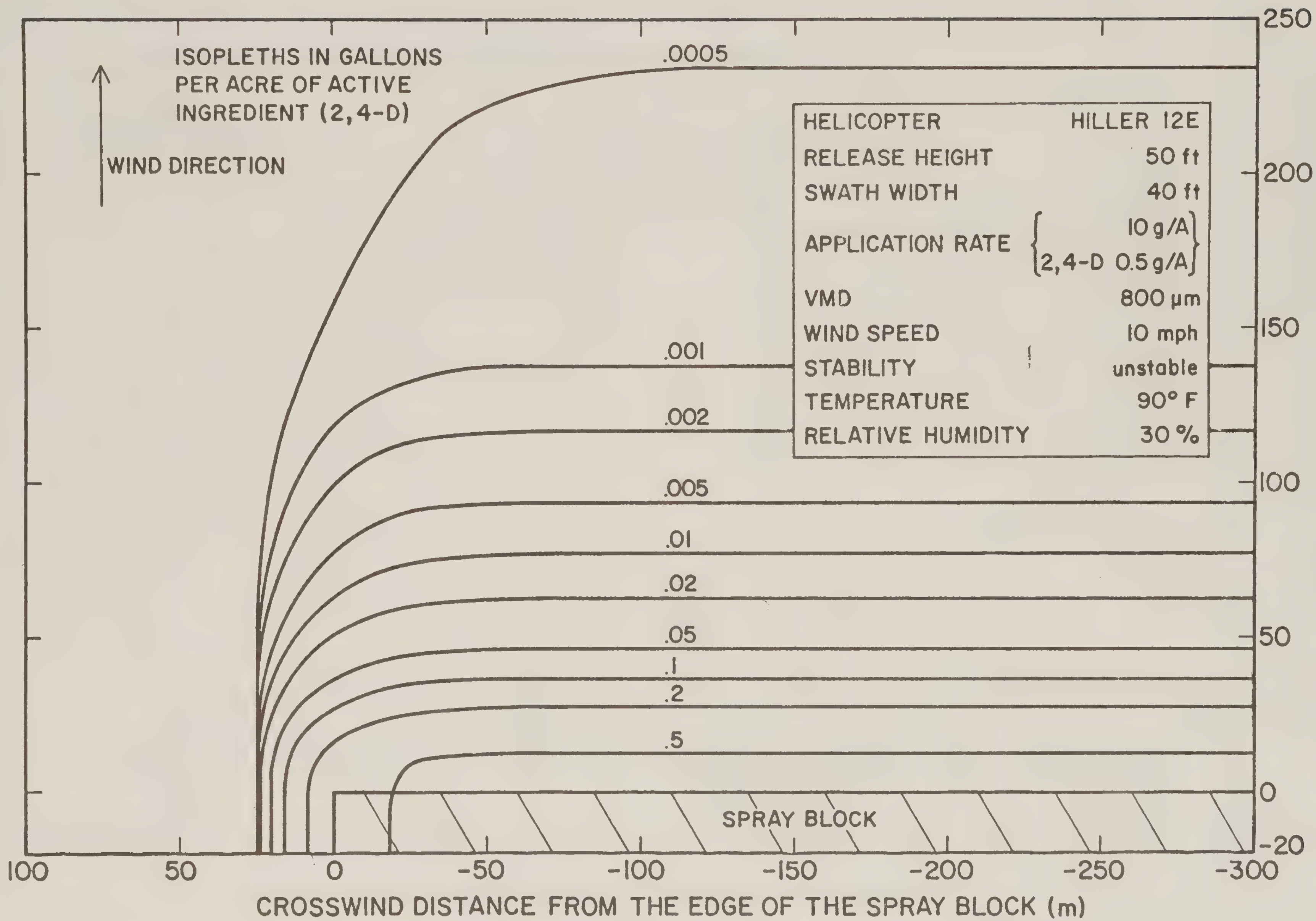

FIGURE 9. Detailed prediction of drift for a release height of 50 ft. and a wind speed of 10 mph.

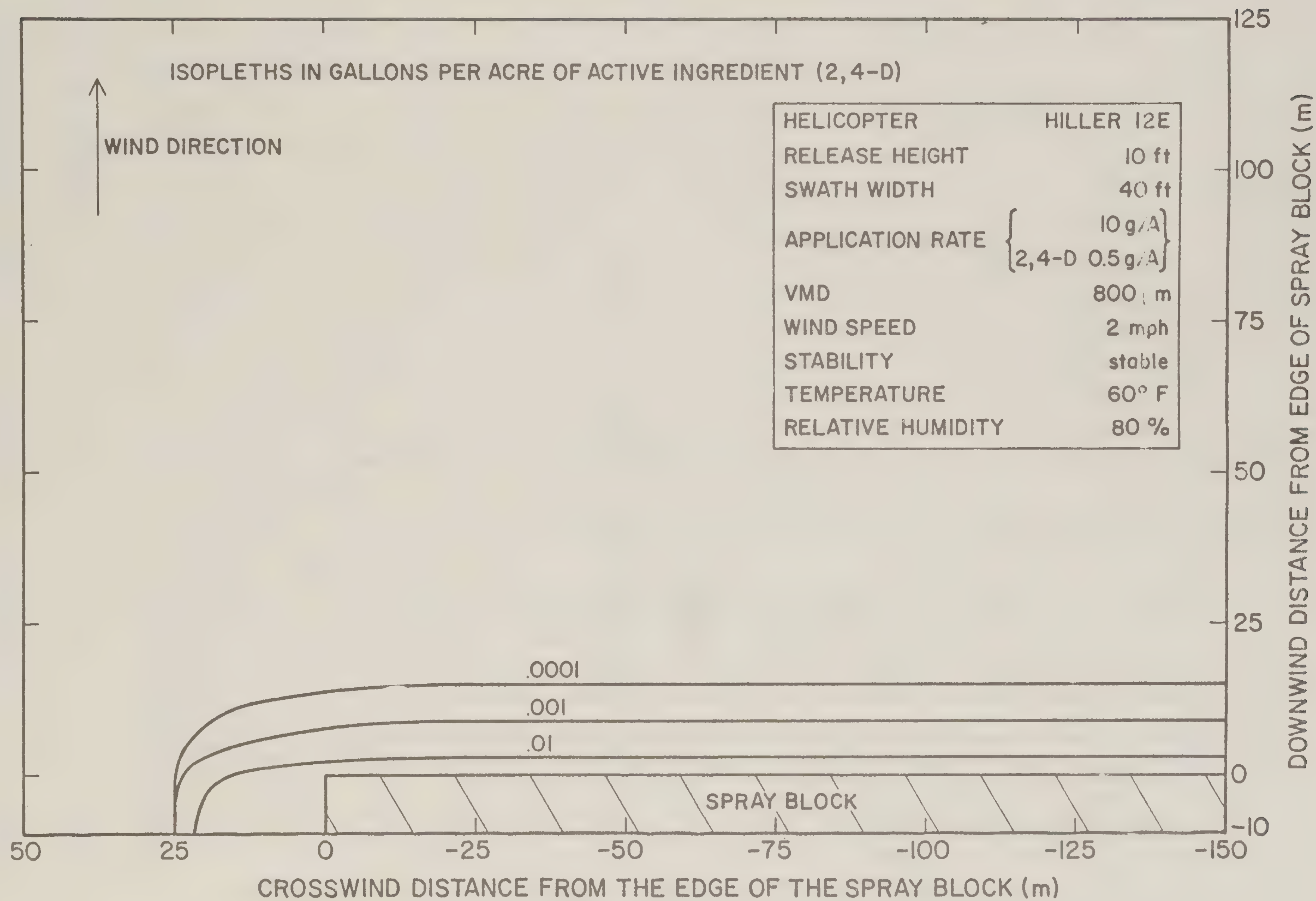

FIGURE 10. Detailed prediction of drift for a release height of 10 ft. and a wind speed of 2 mph.

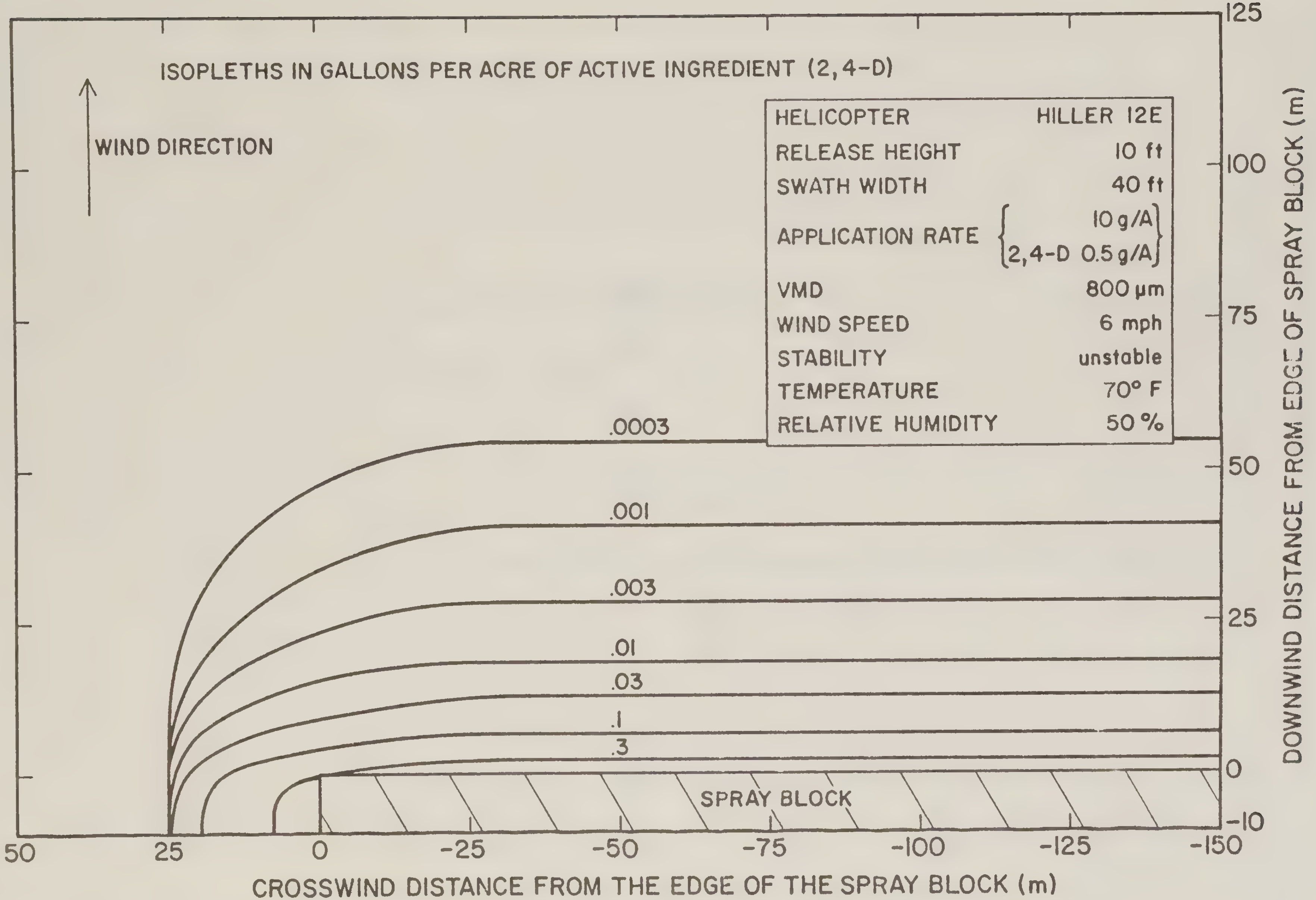

FIGURE 11. Detailed prediction of drift for a release height of 10 ft. and a wind speed of 6 mph.

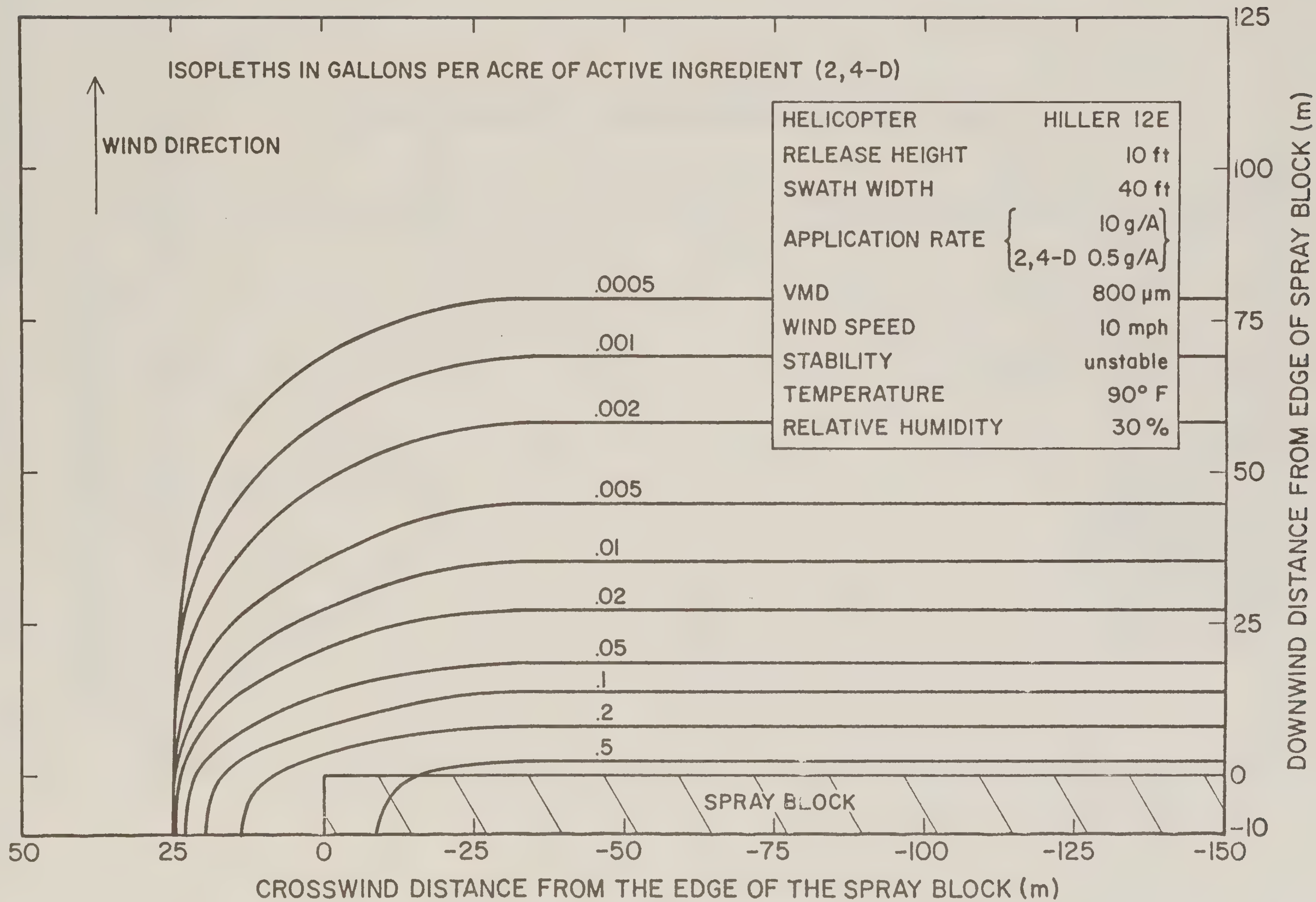

FIGURE 12. Detailed prediction of drift for a release height of 10 ft. and a wind speed of 10 mph.

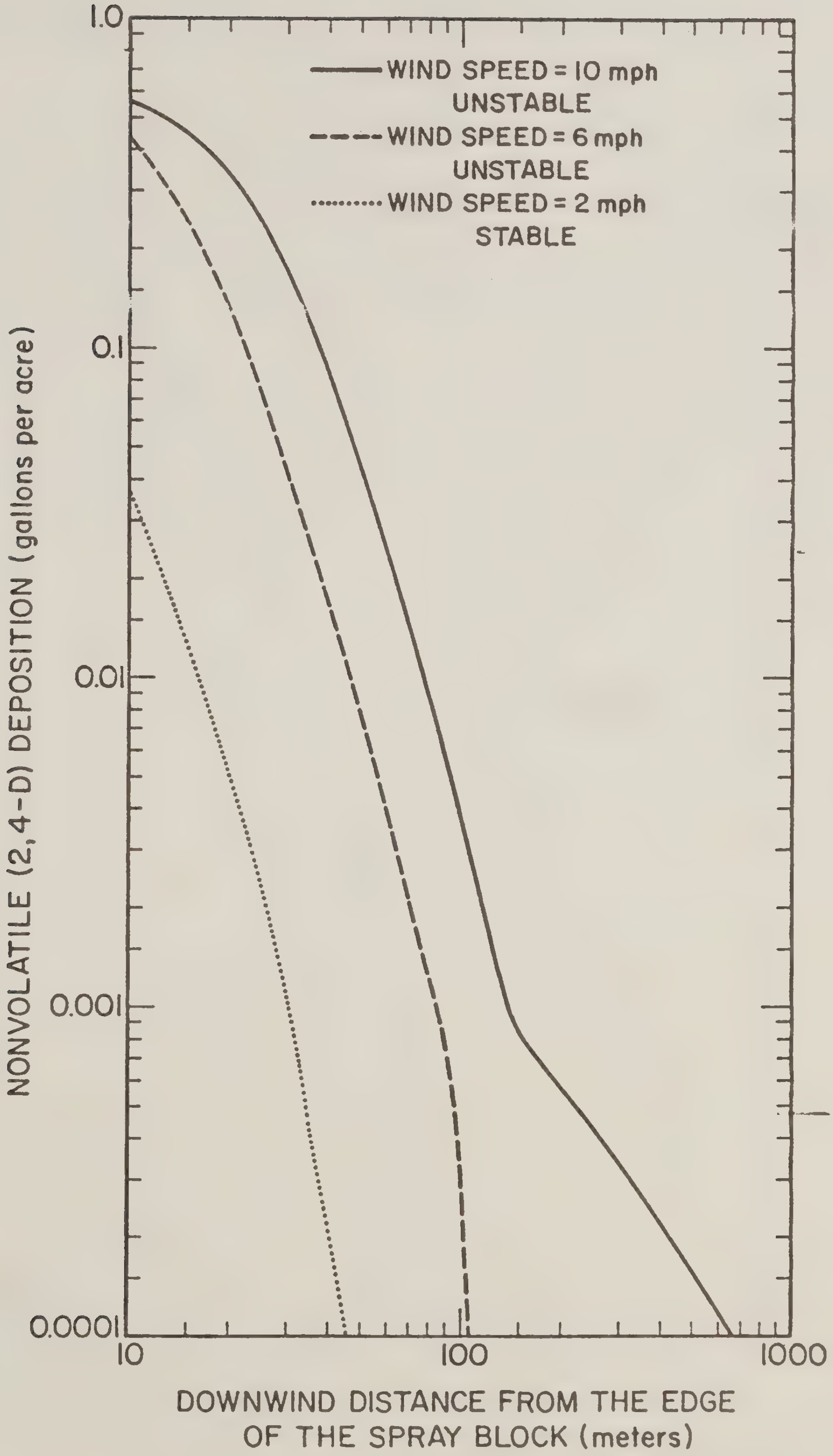

FIGURE 13. Centerline deposition for a spray release from a height of 50 ft. for three meteorological regimes.

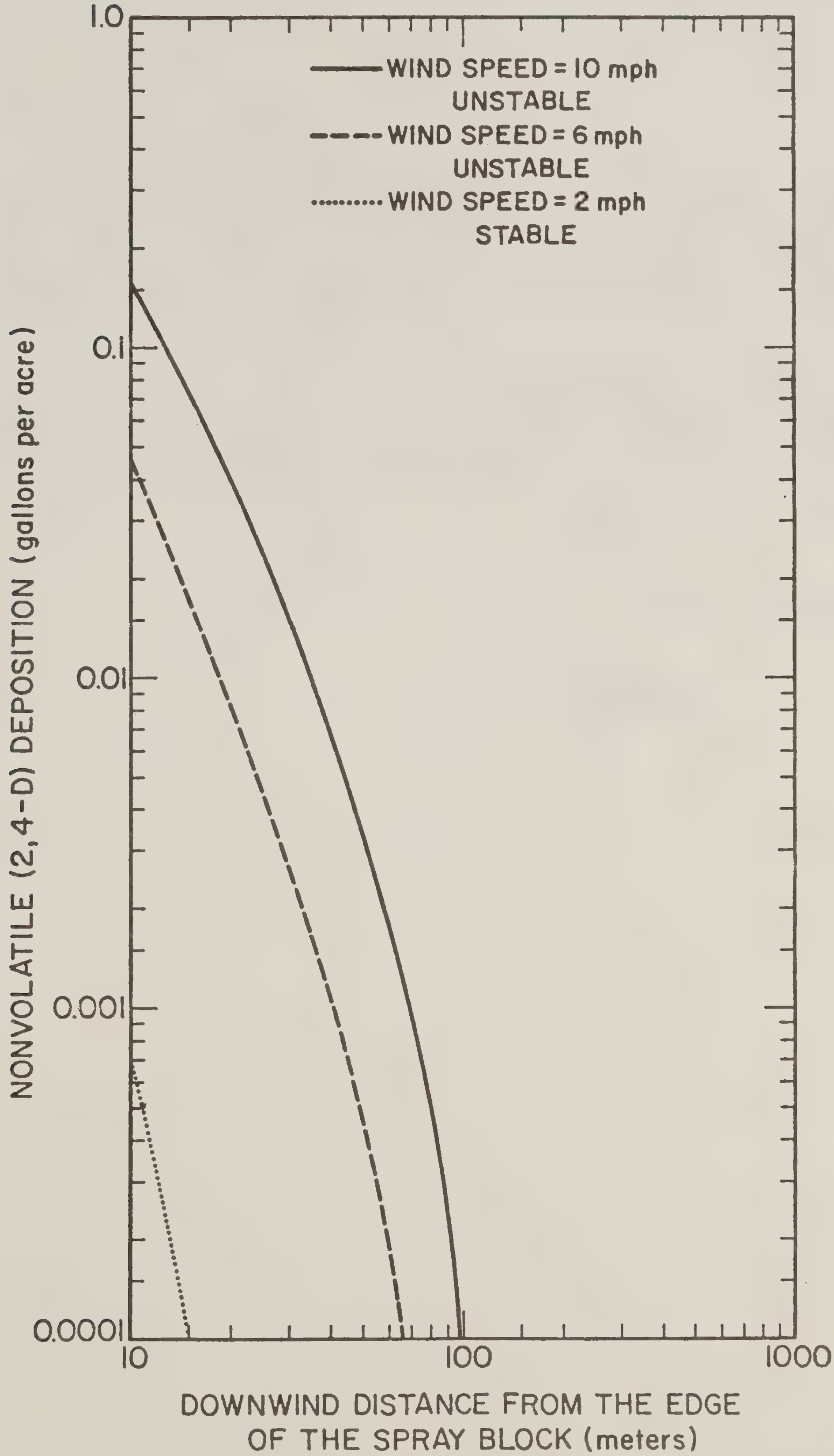

FIGURE 14. Centerline deposition for a spray release from a height of 10 ft. for three meteorological regimes.

REFERENCES

Dumbauld, R. K., J. R. Bjorklund and S. F. Saterlie, 1980: Computer models for predicting aircraft spray dispersion and deposition above and within forest canopies: User's manual for the FSCBG computer program. Prepared under USDA Forest Service contract 53-91S8-9-6127 by H. E. Cramer Co., Salt Lake City, UT. USDA-Forest Service, Forest Pest Management, Davis, CA 95616.

Dumbauld, R. K., 1982. Aerial spray application and long-term drift, In: Proceedings of the Workshop on the Parameterization of Mixed Layer Diffusion. Edited by R. M. Cionco, U. S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, NM.